Conditional Yardstick Competition in Energy Regulation

Timo Kuosmanen[a] *and Andrew L. Johnson*[b]

Motivation

Electricity transmission and distribution networks are critical for the success of competitive market reforms in the energy sector. Today, the electricity transmission and distribution networks around the world require massive investments to mitigate and to adapt to climate change, the changing structure of power generation, changing patterns of consumption, and effectively utilize new and emerging technologies such as the smart grid and energy storage.

Electricity grids are prime examples of network industries with a large fixed cost and a natural monopoly as the most cost efficient industry structure. To provide further incentives to provide acceptable level of service as cost efficiently as possible, many regulators around the world combine price controls with best-practice benchmarking and yardstick competition.

Most regulatory applications of yardstick competition in the energy sector apply either variable cost or total cost benchmarking. Both approaches have their shortcomings. The variable cost benchmark completely ignores the fixed capital, creating a strong incentive for the regulated firms to substitute variable inputs by fixed capital in order to look more competitive. Therefore, application of the variable cost benchmark can result as over-investment, and hence further contribute to the capital bias. In contrast, the total cost benchmarking implicitly assumes all costs to be variable costs, ignoring the risk of investment to fixed capital. A problem of the total cost yardstick is that it punishes owners for such investments that with hindsight turn out to be inefficient. Even a threat of *ex post* punishment may reduce incentive to invest.

Contributions

This paper provides several theoretical, methodological, and operational contributions to improve practical applicability of yardstick competition and benchmarking in the regulation of local monopolies. The theoretical and methodological developments reported in this paper are currently in use in the real-world regulation of the Finnish electricity distribution firms in years 2016-2023.

Our main theoretical contribution is to introduce a new regulation approach referred to as *conditional yardstick competition*. The proposed approach differs from the classic yardstick competition in that the opportunity cost of capital is treated as a fixed cost. Local monopolies are forced to compete against the variable cost frontier, which determines the acceptable level of controllable operational cost, estimated conditional on their fixed capital. Therefore, the conditional yardstick can effectively avoid both the over-investment associated with the variable cost benchmarking and the disincentive to invest associated with the total cost benchmarking.

Our methodological contribution is to develop a novel nonparametric frontier estimation method in the general multi-input multi-output setting under random noise, controlling for observed heterogeneity of firms and their operating environments. We emphasize the importance of shape

a Corresponding author. Department of Information and Service Management, Aalto University School of Business, Espoo, Finland (https://people.aalto.fi/timo.kuosmanen). E-mail: timo.kuosmanen@aalto.fi.

b Department of Industrial and Systems Engineering, Texas A&M University, College Station, Texas 77843-3131, U.S.A. School of Environment and Society, Tokyo Institute of Technology, Tokyo 108-0023, Japan. (https://productivity.engr.tamu.edu/) E-mail: ajohnson@tamu.edu.

The Energy Journal, Vol. 42, SI 1

constraints such as monotonicity, convexity, and constant returns to scale from the perspective of incentives. The main advantage of the proposed approach is that it can impose shape constraints to ensure incentive compatibility of the estimated variable cost frontier, but also accounts for the observed heterogeneity and stochastic noise, similar to the standard econometric techniques.

The various operational contributions of our study stem from the real-world application of the proposed conditional yardstick approach in the incentive regulation of the Finnish electricity distribution firms, conducted in close collaboration with the Finnish energy authority. We discussed in detail the model specification emphasizing incentives, including the specifications of the variable input, fixed input, desirable outputs, undesirable output, and the operating environment. The proposed operational implementation includes several novel features such as the treatment of interruptions as an undesirable output and the use of the connection points per customer as an exogenous indicator of the operating environment.

Benefits, applications and policy implications

Inefficiency loss of the monopoly is a textbook example of market failure. Forcing local monopolies to compete with their peers in a virtual market place created by the regulator will directly address the root cause of the problem, which is lack of competition. Besides electricity distribution network, conditional yardstick competition is applicable to other network industries, such as natural gas distribution networks, district heating, water and sewage systems, roads and railroad tracks, and telecommunication networks.

The incentive regulation of electricity distribution firms directly affects the retail price of energy and the market price of the grid companies, and indirectly influences the transition of energy systems to sustainable renewable energy sources. Smarter regulation of the network industries can benefit the customers and the society at large; however, a stable, sound, and predictable regulation environment is also in the long-term strategic interest of the owners of the grid companies.